Spitzer IRS Observations of Class I Protostars: The Composition and Temperature of Circumstellar Ices

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Class I protostars are characterized by a very red spectral energy distribution peaking in the mid- and far-infrared. Using the Infrared Spectrograph (IRS) on board the Spitzer Space Telescope, we have obtained 5–8 μm spectra of 29 class I protostars in Taurus, selected from a study by *Kenyon and Hartmann* (1995). Five of these spectra were presented in an earlier study by *Watson et al.* (2004). All spectra show evidence of the presence of silicates, by virtue of their 9.7 and 18 μm resonances. In addition, a large fraction of the spectra in our sample show absorption features at 6.0, 6.8 and 15.2 μm, indicative of the presence of ices. These features are commonly explained by a mix of CO_2, H_2O and CH_3OH ice, and are found in massive and low-mass young stellar objects (YSOs, e.g. *Gibb et al.*, 2004; *Alexander et al.*, 2003) and may be due to foreground absorption and/or absorption local to the source. Ices local to the source, possibly located in the circumstellar envelope, cause the absorption observed in our spectra (*Watson et al.*, 2004). We are performing a detailed analysis of variations of the shape of the ice absorption features. These variations can be ascribed to differences in the composition, as well as temperature effects. We determine the abundances, column densities and temperature of the ices found in the sources in our sample, and correlate these parameters to the optical depth in the silicate feature. This helps to constrain physical models of the circumstellar environment of class I protostars and ultimately contributes towards a better understanding of the evolution of circumstellar dust disks.

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